Space Weather Technical Forecast

Issued on Thursday, 18 May 2023 at 13:02 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: R1/R2 Likely. Several CMEs undergoing assessment - confidence in continuation of otherwise Quiet geomagnetic conditions now lower.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity rose to Moderate once again through the past 24 hours, with X-ray activity recorded at GOES16 registering a step-change upwards from low-C class prior to 17/1500UTC to instead show occasional mid C-class and above thereafter. The peak flares of the period were a trio of low-end M class, generated from an arriving unnumbered region on the northeastern limb - at 18/0626UTC (M1.0), 18/0655UTC (M1.2) and 18/1147UTC (M2.2). This group was one of up to eight on the current disc.

The most significant regions now on the facing side both lie near the eastern limb, with AR3310 showing as a stable Dhc, but with a possible Mt Wilson delta spot as its main penumbral group (to be confirmed with a more favourable viewing angle). This group gave an M9.6 on 16 May when it was several degrees behind the limb, however has been less active since. Also now occupying the northeastern solar horizon, the most active spot appears very tentatively as a Dko/Beta.

Other spots on the disc were less noteworthy, although there was a period of growth observed in AR3305, 3307 and 3308 into the current UTC day. All remaining regions were either unipolar or else decaying simple dipoles.

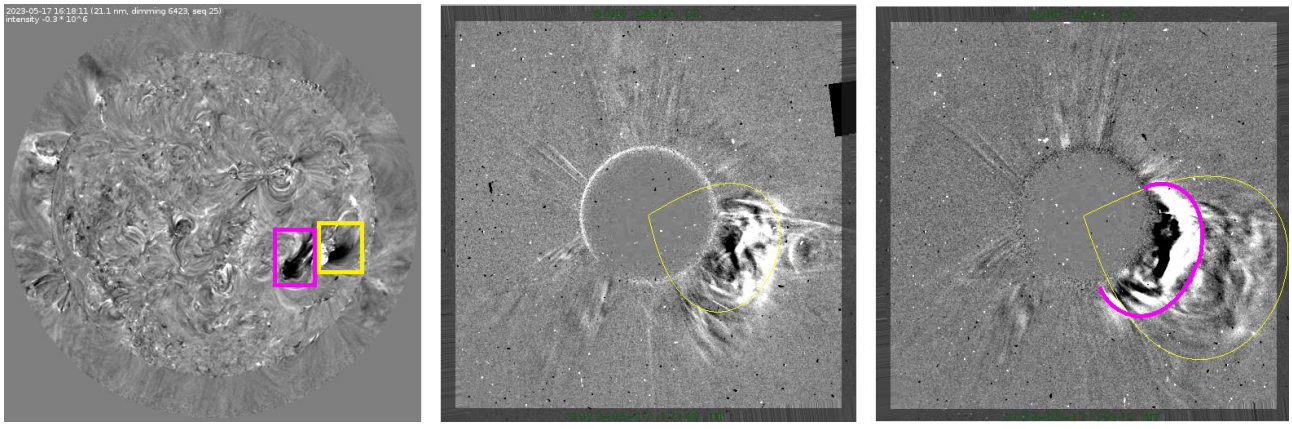

Figure 0: Left: Time-integrated AIA211 dimming showing two CME-generating events undergoing assessment at the time of writing (processing courtesy SIDC ROB). The resultant CME cones can be seen in Lasco C2 difference imagery (centre and right). The filament-related event (magenta) is the more likely to have produced an Earth-directed component (from its inferred lift-off location), although this has yet to be confirmed in modelling.

The current disc is crowded with filaments, and these have proved one of the main monitoring points in the past 24 hours. Given current coronagraph imagery, potentially the most notable

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event(s) took place in the southwestern quadrant from around 17/1500UTC, with a Type II radio emission (speed estimated at 343km/s) from activity in AR3309 and its hitherto straddling filament. This manifested on subsequent coronagraph imagery as a pair of Coronal Mass Ejections (CMEs), apparently seen heading largely south and west. The second of the two appears to be faster, and perhaps with more risk of carrying some form of Earth-directed component from at least the shock. Numerous analyses have been conducted and the latest results are awaited, however very provisionally some minor (possibly G1) influence is perhaps possible later in the four-day forecast period.

The remaining roster of events included: a high latitude northeastern quadrant filament at 17/1830UTC, with no ejecta subsequently visible. Also observed was a slow disappearing filament from the southeast-central disc around 17/2100UTC, which appears to have been re-absorbed. Thirdly, a prominence eruption was observed from the northwestern limb 18/0300UTC, which is not expected to affect Earth; and finally a slow disappearing filament circumscribing the southern crown faded away from 18/0400UTC, with no obvious ejecta.

Confidence in the slate remaining clean for Earth-directed CMEs has fallen significantly by virtue of the above, however none are as yet confirmed in modelling.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured by DSCOVR and ACE at L1, has now begun to relent in its stubborn occupancy of Slightly Elevated levels, falling from early highs in the upper-400s of km/s to finally cross into Background levels in the upper-300s (in ACE data). This may be a final exit from tenuous high latitude coronal hole 02. The solar wind density was level in single figures ppcc, while the IMF was similarly subdued at or below 5nT, with a north-south component erratic and between +3 and -2nT. The phi angle was positive (away from the Sun) throughout.

The net result of the above solar wind measures was for Quiet geomagnetic activity throughout, with a provisional peak of '2-' in the 00-03UTC interval.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as measured at GOES16 showed a continued slow decline in the wake of 16 May's M9.6 from AR3310, having peaked at 0.8pfu - i.e. roughly a decade below S1.

High energy electron flux (greater than 2MeV), as measured at GOES16 was at Normal Background levels. The 24-hour integrated fluence has been well below Active levels. At 18/0001UTC, 2.64e6 integrated pfu was recorded.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is Likely to be Moderate, with a Slight Chance of X-class, arising mainly from the arriving combination of AR3310 and its northeastern unnumbered compatriot. No significant regions leave the disc in the period, and no further large regions are expected to arrive, leading to a level risk throughout.

Solar Wind / Geomagnetic Activity: No CMEs currently feature in the forecast, however confidence in this assertion is low, with modelling results awaited. Any resulting CME influence would be more likely later in the period given the modelled speeds.

The sole fast wind due in the period should arise from the doublet of CH03/04/-, with MOSWOC Enlil modelling suggesting an onset of Friday 19 May, continuing through 20 May before waning. This may offer a token Slight Chance of G1 - the peak of the period should no CME influence materialise.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux carries

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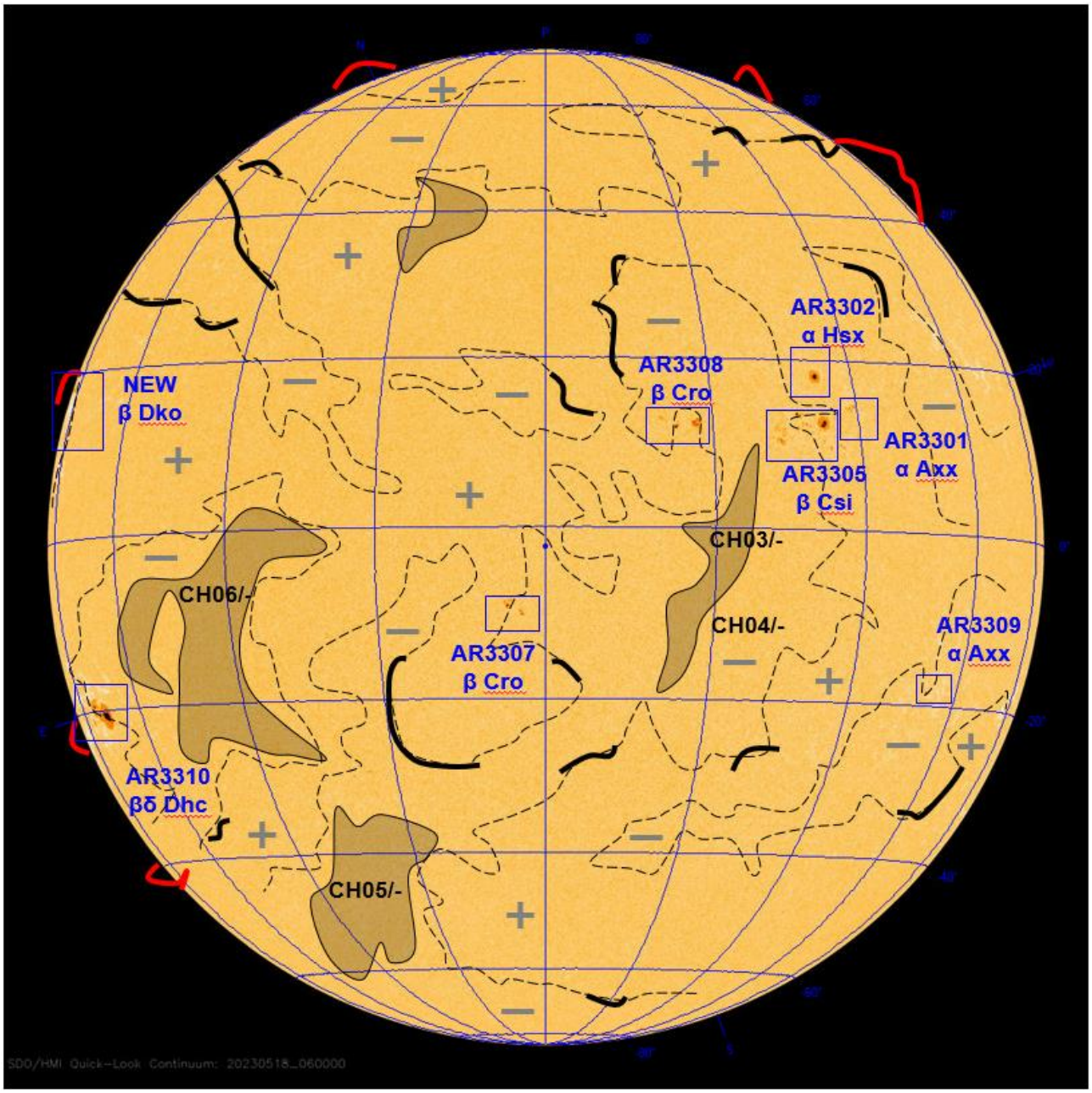
a daily Slight Chance of S1, largely as a result of the eastern hemisphere spots, with this very gradually rising over the four days.

High energy electron flux (greater than 2MeV) should most likely remain at Normal Background levels, with a slight uptick possible in the wake of minor CH03/04/- from later in the UTC weekend. Active fluence is not expected.

Figure 1. Solar Analysis Valid 18/0600UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Given the number of filaments and recent lift-offs, the geomagnetic forecast is likely to prove more changeable than is typical. Coronagraphs are polluted by some of the larger events, which may hide visually more minor but more impactful CMEs.

No CMEs currently feature in the forecast, however confidence in this assertion is low, with modelling results awaited. The main area of interest is events from the southwestern quadrant on and after 17/1500UTC, with instability in the minor and decaying spot group AR3309 perhaps also helping to trigger a filament eruption here. Any resulting CME influence would be more likely later in the period given the modelled speeds.

The sole fast wind due in the period should arise from the doublet of CH03/04/-, with MOSWOC Enlil modelling suggesting an onset of Friday 19 May, continuing through 20 May before waning. This may offer a token Slight Chance of G1 - the peak of the period should no CME influence materialise.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	10	5	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil confirmed, but analyses pending.

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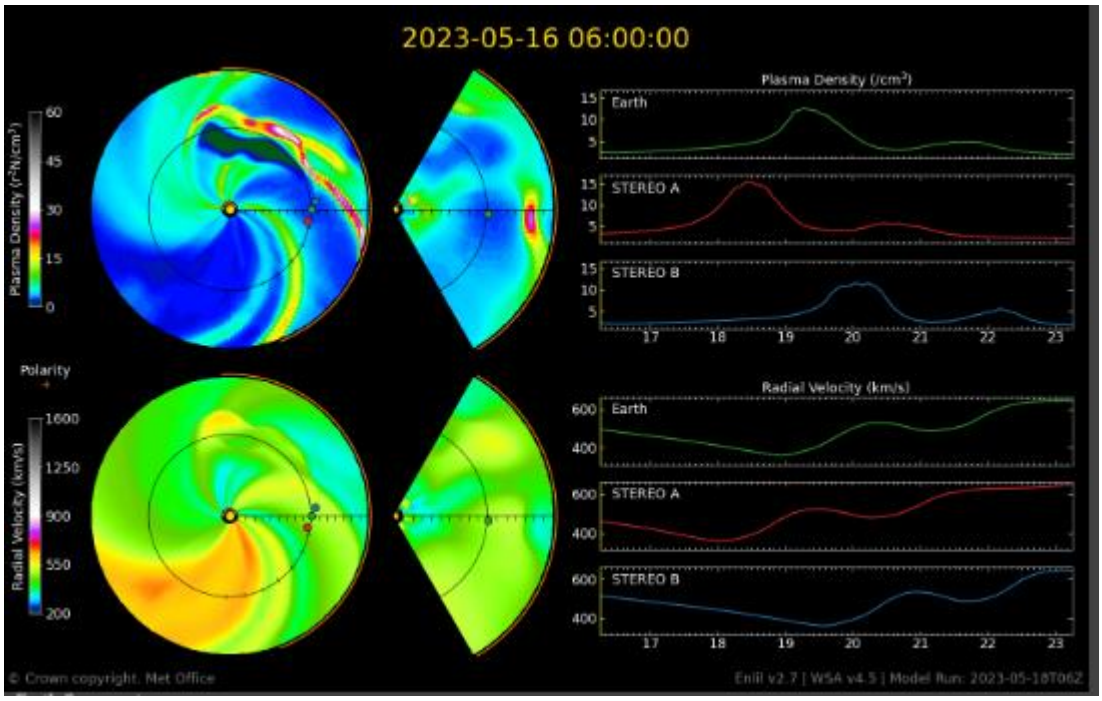
Figure 2: Latest MOSWOC Enlil run. At the time of writing the 17 May CMEs were not available. Enlil can be seen to suggest an increasing solar wind as a result of CH03/04 on 19 May. This may then increase further outside the scope of this forecast period due to another fast wind, perhaps CH06/-.



Radio Blackouts - X-Ray Flares:

There are now up to eight sunspot regions on the disc, with the eastern solar horizon now harbouring AR3310 and a new region, both of which dominate in terms of recent flare history and apparent complexity. The remainder of the disc is currently contributing little to this, however recent growth in AR3305, 3307 and 3308 was observed.

The daily risk of significant flares has been increased relative to the raw values, as limb foreshortening effects are preventing determination as to whether there is a Mt Wilson Delta spot in AR3310, and almost entirely inhibiting analysis of the new region to its north. M-class flares are now considered Likely throughout, while the risk of X-class has been raised to 15%.

Regarding the trend in risk levels, no significant regions leave the disc in the period, and no further large regions are expected to arrive, leading to a level risk throughout.

X Ray Flares	**Level**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability			**(%)**	**(%)**	**(%)**	**(%)**
Active	**R1-R2 M Class**	No	60	60	60	60
Very Active	**R3 to R5 X Class**	No	15	15	15	15

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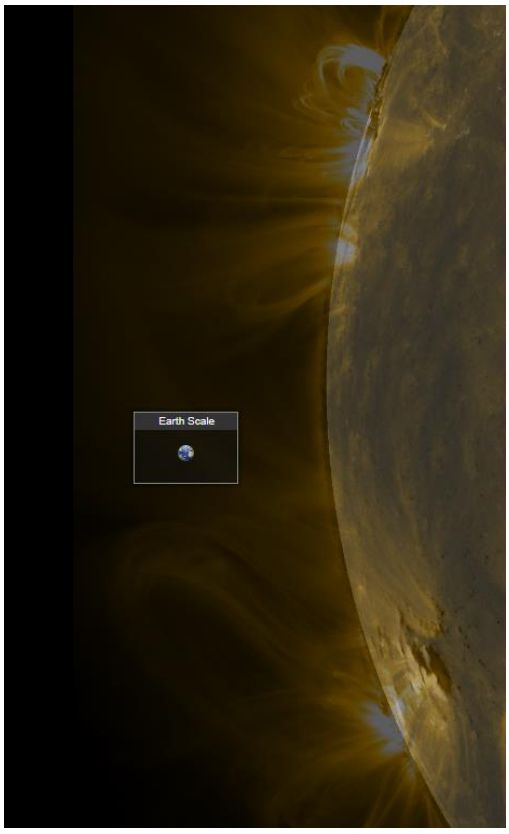
Figure 3: X-ray flare loctions of C-class and above (white pixels) from the past three days (image courtesy of SIDC ROB). Note the diffuse response from AR3310, which was over the limb for a lot of its contribution, and the X-rays seen at Earth were from higher in the corona. Its northeastern compatriot is more anchored and precise by comparison. The remainder of the disc can be seen to have contirbuted little, although the 'stripe' of flares in the southwest may have included noteworthy CME(s) – this final point TBC.

Figure 4: The arriving eastern limb regions, as seen at 18/0900UTC in AIA171 and HMIB. Processing courtesy of helioviewer.org. Earth shown for scale.



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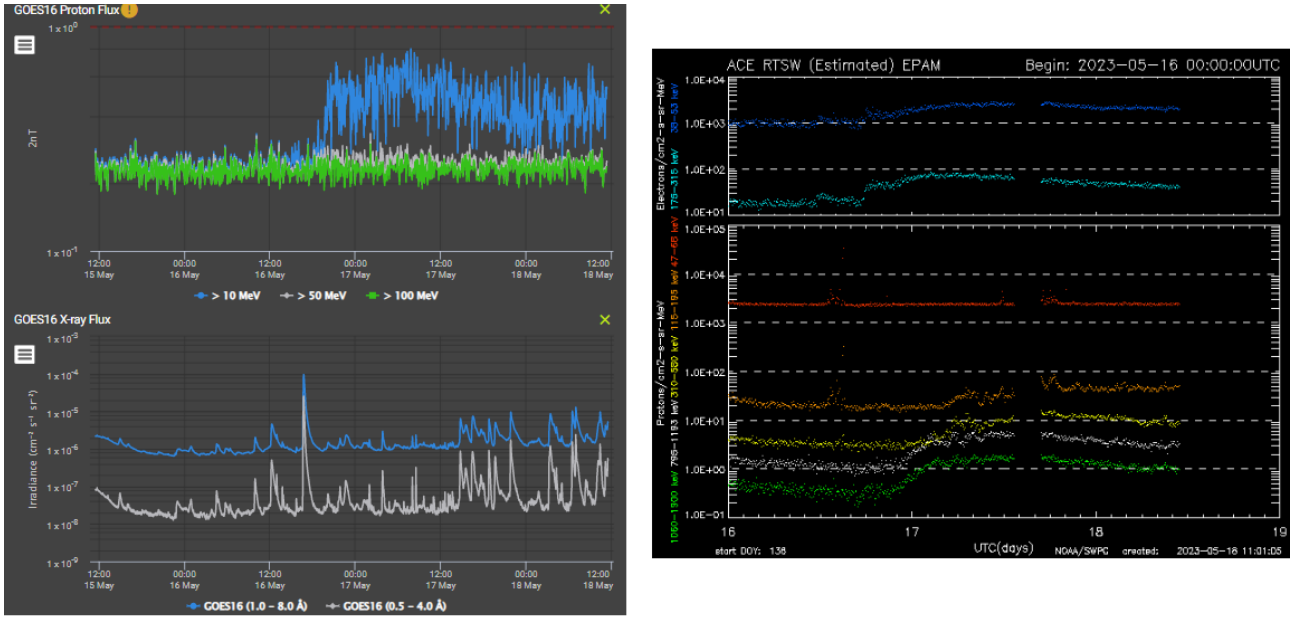
Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16 is now gradually relaxing back to resting Background levels, having become slightly enhanced to an eventual 10MeV peak of 0.8pfu in the wake of the M9.6 flare from 16 May.

While AR3310 is perhaps the most likely source for further such activity, this is now being joined by both a new region in the northeast and also a far-sided western solar hemisphere presumed region - given recent CMEs from this vicinity. Because limb foreshortening effects are hampering proper analysis of the eastern limb groups, and also because of the number of unobservable features that may contribute, the risk of S1 is held slightly above the raw disc value. It also increases on balance because of the westward progression of the visible groups.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Past three days in high-energy proton levels at GOES16 (top left), with subsequent near immediate response to M9.6 (lower left) in ACE EPAM LEMS (right). The most recent enhancement peaked at 0.8pfu for 10MeV protons, and is in very gradual decline, with the drawn-out reponse likely to be due to its eastern emission location.



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High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) has remained at normal Background levels over the past 24 hours.

There is only one source of fast wind possible in the four-day period, the minor coronal hole doublet of CH03/04/-. This is a persistent feature, but its tenure was entirely masked by a CME-derived G4 on last rotation. MOSWOC Enlil's current thoughts of a gradual rise to 450-500km/s through 19 into 20 May is therefore accepted with low confidence, which may eventually result in a Slight Chance of Active, although given the expected small stature and duration of the fast wind, this is not thought particularly likely.

GEO Electron Environment	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ 2 MeV ≥ $1x10^{8}$**	No	1	1	5	20
Very Active	**≥ 2 MeV ≥ $1x10^{9}$**	No	1	1	1	1

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